739/37384/306

PATENT

Certificate of Mailing by "Express Mail"

Mailing Label Number EL666710877US

Date of Deposit: December 21, 2000

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office Box Addressee" service under 35 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

CHERYL K. JAROT

ANTI-LOCK BRAKE SYSTEM FOR A VEHICLE, SUCH AS A TRUCK OR A TRAILER, INCLUDING BACK-UP ALARM AND/OR LAMPS

This application claims the priority of provisional application Serial No. 60/171,741, filed on December 22, 1999, and entitled "Sensing System For a Trailer Wheel".

BACKGROUND OF THE INVENTION

This invention is generally directed to an anti-lock brake system (ABS) or an electro-pneumatic brake system (EBS) for a vehicle, such as a trailer, which is used to perform a function of the vehicle when it is in reverse. More particularly, the invention contemplates an ABS or EBS which is used to power an audible back-up alarm and/or a back-up lamp when a trailer is in reverse.

739/37384/306

PATENT

ANTI-LOCK BRAKE SYSTEM FOR A VEHICLE, SUCH AS A TRUCK OR A TRAILER, INCLUDING BACK-UP ALARM AND/OR LAMPS

This application claims the priority of provisional application Serial No. 60/171,741, filed on December 22, 1999, and entitled “Sensing System For a Trailer Wheel”.

BACKGROUND OF THE INVENTION

This invention is generally directed to an anti-lock brake system (ABS) or an electro-pneumatic brake system (EBS) for a vehicle, such as a trailer, which is used to perform a function of the vehicle when it is in reverse. More particularly, the invention contemplates an ABS or EBS which is used to power an audible back-up alarm and/or a back-up lamp when a trailer is in reverse.

Historically in the North American trucking industry, there has been a limited number of electrical connections available between a tractor and a trailer. One connector is available. This is defined by the Society of Automotive Engineers (SAE) J560 standard and the following circuits are available:

1	White	Ground return to tractor
2	Black	Clearance, side marker and identification lamps
3	Yellow	Left turn signal and hazard lamps
4	Red	Stop lamps (and anti-lock brake system power)
5	Green	Right turn signal and hazard lamps
6	Brown	Tail and license plate lamps
7	Blue	Auxiliary

Pin 7 has been considered a general purpose pin which was used as the particular vehicle operator required. For example, Pin 7 can be used to light an interior lamp (dome lamp) in the trailer or to light a back-up lamp. Two disadvantages become apparent. First, if the owner wanted both back-up lamps and dome lamps, this could not be accommodated. Second, since tractors and trailers are constantly intermixed, incompatibility becomes an issue. For example, if a tractor is wired to turn on trailer back-up lamps automatically, this would just light the interior lamps on a trailer which used the auxiliary circuit for this purpose.

Since March of 1997 for tractors, and since March of 1998 for trailers, the use of this circuit on Pin 7 has largely been standardized to supply power, but only when the ignition is switched on. This circuit powers the ABS on the trailer. The circuit on Pin 7 may also be utilized by other devices. This has helped to standardize the use of this circuit. The downside, however, is that there is now no circuit available for auxiliary functions.

It should be noted that if an operator wants to have an additional connector to handle one or more auxiliary functions, this is entirely possible. This works well for a particular tractor-trailer combination, or at best within a particular small fleet. It is not a mainstream solution because tractors and trailers are constantly intermixed. Even if

tractors and trailers always stayed within the same fleet, it would still be practically impossible to re-equip an entire large fleet which could easily have more than ten thousand trailers.

Concentrating in particular on audible back-up alarms and back-up lamps, these are very desirable to have on trailers. There is an obvious advantage when backing up at night. An audible back-up alarm is very desirable, even during daytime when backing up in areas busy with pedestrian traffic. A construction site is a good example of this type of environment. An alarm at the back of the trailer is preferable to an alarm mounted on the tractor which may be forty-five feet forward and may not be heard in a noisy environment.

ABS technology provides a mechanism by which an audible back-up alarm and/or a back-up lamp can be practically and economically implemented on a trailer. It should also be noted that, in the future, more advanced brake controls known as Electro-pneumatic Brake Systems (EBS) may replace the basic ABS of today. EBS generally incorporate the ABS function and also require wheel speed sensors.

As shown in FIGURE 1, the wheel speed sensors provide wheel speed information to the electronic control module (ECM) of the anti-lock brake system. The ECM signals the pneumatic control module (PCM) of the anti-lock brake system to modify air pressure level at the brake chambers. The braking level is controlled so that the wheels continue to rotate, or at least rotate most of the time, even during heavy braking. The overall process is described in detail in numerous patents and in the pending United States patent application Serial No. 09/306,921, which is commonly owned by the assignee herein.

The current industry standard sensing mechanism uses a variable reluctance (VR) sensor together with a toothed ring which is fitted to the back of the wheel hub. The sensor consists of a magnet, a coil of wire and a metal pole piece, all of which are enclosed in a cylindrical casing of about 2½ inches long and 5/8 inches diameter. The toothed ring generally has 100 teeth.

As the wheel rotates, magnetic flux through the coil in the sensor is present to

a greater or lesser degree depending on whether a tooth is directly over the pole piece in the face of the sensor. This changing flux induces an alternating voltage in the coil which is approximately sinusoidal. The frequency is proportional to the speed of the wheel and the proportionality relationship is about 14 Hertz (cycles per second) per mph. The frequency signal is used by the ECM to determine the speed of the wheel. The amplitude of the signal is highly dependent on the gap between the face of the sensor and the toothed ring and it also increases with wheel speed. Generally the amplitude information is not used directly by the ECM.

The sensor is located in a bore in a metal block which is welded to the axle behind the hub. A sleeve within the bore retains the sensor so that its face remains close to the toothed ring.

The VR sensors do not measure "zero" speed. The VR sensors generate voltage in response to changing magnetic flux but the VR sensors do not respond to absolute flux levels. As such, the VR sensors cannot determine whether the pole of the sensor is opposite a tooth or a gap if the ring is stationary. Very slow rates of rotation, for example below one mile per hour depending on the sensor gap, do not generate enough alternating voltage for the ECM to determine that rotation is actually occurring.

Passenger car ABS sensing technology sometimes uses "active" sensors. The active sensors have a semiconductor-type element to replace the coil in conventional VR sensors. This semiconductor-type element measures the actual level of magnetic flux, not a rate of change. These active sensors can measure close to "zero" speed as the active sensors respond to each change from a tooth to a gap, or vice versa, regardless of speed. For active sensors, the toothed ring can be replaced by a circular multi-pole magnet which may be considered to be an exciting ring.

In addition to the sensing element, active sensors also require integrated electronic circuitry to amplify the signal to reasonable levels for transmission to the ECM. Hence, active sensors use several "active" electronic components. Either a two or a three-wire connection to the ECM is required. An approximate square wave

signal with levels of zero and five volts would be typical for a three-lead design. The three leads are power, ground and signal. For a two-lead design, two different current levels with typical values of seven mamps and fourteen mamps would be used. The two leads are power and ground, with current variation being sensed by the interface electronics.

From a functional perspective, "zero" speed sensing of itself, does not provide a significant advantage for a simple trailer ABS product. In certain circumstances, however, this active technology provides implementation advantages. Also, as will be discussed here, and in related patent applications owned by the assignee herein, this technology allows easier implementation of certain features which can be added to a basic trailer ABS product.

As noted, prior art ABS have wheel speed information available to them. Prior art ABS do not have information as to whether rotation is forward or reverse.

In the production machine industry, such as forging machines, reverse speed sensing arrangements have been used. Reverse speed sensing is frequently implemented using a pair of sensors with a technique known as quadrature. Essentially, the sensors are placed an integral number of tooth spacings away plus one-fourth of a tooth spacing. If a tooth spacing is considered to be 360 degrees, then the one-fourth corresponds to 90 degrees. By checking whether a positive edge follows a positive edge, or whether a negative edge follows a positive edge, the direction of rotation of the wheel can be detected. Techniques for doing this are well-known to those familiar with the state of the art.

FIGURE 2 is a suitable logic circuit which implements this function. Signals A and B show two square waveforms in quadrature. Signals A and B are assumed to originate from two separate sensors appropriately spaced on the toothed ring. Square waves like those shown can be produced directly by active sensors. A high level represents when the approximately sinusoidal voltage from the sensor is positive, and a low level represents when the approximately sinusoidal signal from the sensor is negative. Suitable signal conditioning circuits for VR sensors are in common use and

are well-known to those skilled in the art.

Assuming suitable square wave signals, A and B, the circuit of FIGURE 2 provides a possible implementation of the electronics required to interpret the quadrature signals. The flip-flop clocks the information from input to output when there is a positive edge at its clock input. Thus, the flip-flop clocks on positive edges of the A waveform. It will be seen that the output C is low for forward rotation, and the output C is high for reverse rotation. The C line is fed to a controller which operates under stored program control. The stored program makes the decision to provide power to the alarms and lamps, or for other purposes.

While conventional VR sensors are acceptable for determining direction, some issues arise. First, two separate sensors are required. Second, precise mounting of the sensors are required, particularly in relation to each other. There is also the issue that two separate signal conditioning circuits are required. Speed sensitivity of the output of a VR sensor is also a concern. At a very low speed, there is only a very low amplitude signal and it would be desirable to power the alarm and/or lamps, even when moving at very slow speed.

The present invention provides novel structure for sensing the direction of the trailer using ABS or EBS. Other features and advantages of the present invention will become apparent upon reading the attached specification in combination with a study of the drawings.

OBJECT AND SUMMARY OF THE INVENTION

A general object of the present invention is to provide an anti-lock brake system (ABS) or an electro-pneumatic brake system (EBS) for performing a function of a vehicle when the vehicle is in reverse.

Another object of the present invention is to provide an ABS or EBS which is used to power an audible back-up alarm and/or a back-up lamp when the vehicle is in reverse.

Briefly, and in accordance with the foregoing, the present invention discloses an ABS or EBS for a vehicle, such as a trailer or a truck, which activates a function on the vehicle, such as an audible back-up alarm and/or a back-up lamp, when the vehicle is reversing. A sensor member is mounted on an axle of the vehicle is used to determine the speed of rotation of the wheel and to determine the direction of rotation of the wheel by sensing an exciting ring which rotates with the wheel. A controller processes information from the sensor member regarding the wheel speed and the direction of wheel rotation. A circuit causes the function on the vehicle to be performed when it is activated by the controller.

BRIEF DESCRIPTION OF THE DRAWINGS

The organization and manner of the structure and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, wherein like reference numerals identify like elements in which:

FIGURE 1 is a block diagram of a prior art anti-lock brake system;

FIGURE 2 is a prior art schematic for sensing direction;

FIGURE 3 is a block diagram of an anti-lock brake system (ABS) or an electro-pneumatic brake system (EBS) which incorporates the features of the present invention;

FIGURE 4 is a side elevational view of a trailer and a partial side elevational view of a tractor on which the ABS or EBS which incorporates the features of the present invention is used;

FIGURE 5 is a partial cross-sectional view of a wheel mounting apparatus which includes a wheel speed sensor which incorporates the features of the invention;

FIGURE 6 is an enlarged section of FIGURE 5;

FIGURE 7 is a perspective view of a portion of the wheel speed sensor;

FIGURE 8 is an enhancement circuit which is used in the present invention;

FIGURE 9 is an electronic schematic of an implementation of the present invention;

FIGURE 10 is a schematic of the overall implementation of the present invention; and

FIGURE 11 is a schematic of the schematic of the wheel speed sensor and ABS.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

While the invention may be susceptible to embodiment in different forms, there is shown in the drawings, and herein will be described in detail, a specific embodiment with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that as illustrated and described herein.

A block diagram for an anti-lock brake system (ABS) or an electro-pneumatic brake system (EBS) for a trailer 26 in accordance with the present invention is shown in FIGURE 3. The present invention provides a wheel sensing arrangement, more specifically described with respect to FIGURE 9, which provides speed and direction information to a controller, such as an electronic control module (ECM). Power (12 Volts) to the ECM is supplied from pin 7 of the J560 connector 18 between the tractor 16 and the trailer 26. The ECM controls a pneumatic control module (PCM) which controls the air brake mechanism on the trailer 26. The ECM also controls the function of circuitry, such as a back-up system which is used to sound an audible back-up alarm, which is performed using suitable means, and/or light a back-up lamp, as described herein. The ECM of the ABS or EBS signals the PCM of the ABS or EBS to modify air pressure level at the brake chambers. The braking level is controlled so that the wheels continue to rotate, or at least rotate most of the time, even during heavy braking. The overall process is described in detail in numerous patents and in the pending United States patent application Serial No. 09/306,921, which is commonly owned by the assignee herein and which is incorporated by reference. The present invention uses a wheel speed and direction sensor 20 which is mounted in the end of an axle 22 of a wheel mounting apparatus 24 of the trailer 26 as described herein.

The wheel mounting apparatus 24 generally includes the axle 22, a wheel hub assembly 28 and an air brake mechanism. The air brake mechanism is of known construction and as such is not described in detail herein.

The axle 22 is fixedly mounted on the body of the trailer 26 by suitable means and is formed from a hollow tube (only one end of which is shown). The ends of the hollow axle 22 have a thread form on the exterior surface thereof. The inner surface of each end of the axle 22 has a portion 30 which has an increased inner diameter relative to an inner diameter of a central portion of the axle 22. The axle 22 is formed from a suitable strong rigid material.

The wheel hub assembly 28 is mounted on the end of the axle 22 and generally surrounds the axle 22. The wheel hub assembly 28 includes a wheel hub 32, a plurality of inner bearings 34, a plurality of outer bearings 36, and a metal hub cap 38. The wheel hub 32 is attached to the brake drum by suitable known means, such as bolts. The wheel hub 32 has a portion 33 which is precisely machined in the end thereof.

The inner and outer bearings 34, 36 are mounted between the wheel hub 32 and the axle 22 by respective bearing cups 40 and bearing cones 42 and allow for rotation between the fixed axle 22 and the rotating wheel hub assembly 28 and air brake mechanism. The outer bearings 36 are mounted in the portion 33 such that the bearing cups 40 abut against a shoulder formed by the portion 33. This precisely mounts the outer bearings 36 on the wheel hub 32 and therefore, relative to the axle 22. The inner and outer bearings 34, 36 are mounted at locations which are spaced apart from each other along the length of the axle 22 such that a cavity 44 is provided between the wheel hub 32, the axle 22 and the bearings 34, 36. A bath of oil or semi-fluid synthetic grease is contained within the cavity 44. The bearings 34, 36 are lubricated by the bath of oil or semi-fluid synthetic grease contained therewithin.

The hub cap 38 surrounds the end of the axle 22 and prevents the oil or grease from leaking out of the end of the wheel hub assembly 28. The hub cap 38 includes an outer end wall 46, a first side wall 48, a second side wall 50, a third side wall 52 and an inner end wall 54. The walls 46, 48, 50, 52, 54 are integrally formed with each other. The outer end wall 46 is circular. The first side wall 48 is generally perpendicular to the outer end wall 46 and has a first end connected to the outer end

wall 46 and tapers from its first end to its second, larger end. The second side wall 50 has a first end connected to the second end of the first side wall 48 and tapers from its first end to its second, larger end. The third side wall 52 has a first end connected to the second end of the second side wall 50 and tapers from its first end to its second, larger end. The inner end wall 54 is annular and is generally perpendicular to the third side wall 52 and has a first end connected thereto and extends outwardly therefrom. The inner end wall 54 is parallel to the outer end wall 46. A plurality of apertures are provided through the inner end wall 54 through which the hub cap 38 is attached to the end of the wheel hub 32 by suitable means, such as bolts 56.

The third side wall 52 has an end portion 55 which extends past the inner end wall 54. When the hub cap 38 is mounted on the wheel hub 32, the end portion 55 seats within the portion 33 of the wheel hub 32 and abuts against the cones 40 of the outer bearings 36. This locates the hub cap 38 precisely on the wheel hub 32 and on the axle 22.

A washer 58 is mounted on the threaded end of the axle 22 and bears against the bearing cones 42 of the outer bearings 36. An inner adjusting nut is 60 threaded onto the threaded end of the axle 22 and bears against the washer 58. The adjusting nut 60 is locked onto the axle 22 by threading an outer jam nut 62 on the threaded end of the axle 22. The adjusting nut 60 is used for properly positioning the bearing cups 42 of the outer bearings 36. The washer 58, the inner adjusting nut 60 and the outer jam nut 62 are proximate to the third side wall 52 of the hub cap 38. The washer 58, the inner adjusting nut 60 and the outer jam nut 62 do not completely fill the space between the axle 22 and the hub cap 38 such that a space is formed therebetween. It is to be understood that other components can be threaded on the end of the axle 22 to position the outer bearings 36.

A freeze plug 64 sits within and fills the end portion 30 of the axle 22. The freeze plug 64 has a circular central portion 66 and an annular skirt 68 which depends therefrom. The skirt 68 tightly engages with the inner surface of the end portion 30 of the axle 22. A central aperture 70 and a second aperture (not shown) therethrough

which is offset from the central aperture 70 are provided through the central portion 66 of the freeze plug 64. A grommet (not shown) is provided within the second aperture. The freeze plug 64 prevents oil or grease from entering into the axle 22 and prevents debris from going from within the axle 22 outwardly therefrom.

The wheel speed and direction sensor 20 includes a sensor member 72 and an exciting ring 74. The sensor member 72 is mounted in the end of the axle 22 and is spaced from the freeze plug 64. The exciting ring 74 is mounted on the hub cap 38 by a mounting wheel 75.

The sensor member 72 includes a plastic body 76 which extends partially into the end of the axle 22 and extends outwardly therefrom, and a plastic cover 78 which covers the section of the body 76 which extends outwardly from the end of the axle 22. The cover 78 is suitably secured to the body 76. A recess is formed between the body 76 and the cover 78. A central aperture 80 is provided through the body 76 and the cover 78 and aligns with the central aperture 70 through the freeze plug 64. A plurality of L-shaped vents 81 are provided through the periphery of body 76 to provide an air passageway from the space between the freeze plug 64 and the body 76 and the space between the sensor member 72 and the hub cap 38.

The body 76 of the sensor member 72 is fastened to the axle 22 by a bolt 82 which is mounted in the central aperture 80 through the body 76. The bolt 82 threads with the central aperture 70 through the freeze plug 64. The thread form in the freeze plug 64 may be pre-tapped or may be generated using a thread forming bolt.

The central aperture 80 in the body 76 allows for the possibility of an air passage through the body 76 if a hollow bolt 82 is utilized as shown. This allows for the incorporation of a central tire inflation (CTI) in the present system. CTI systems automatically keep tires inflated by passing air from a compressed air reservoir mounted on the trailer 26 to the tires. One possible implementation of a CTI system with the present invention passes air through a tube in the hollow axle 22, then through a swivel connection with a rotating seal to air fittings on the outside of the hub cap 38. The air is then piped to the inflation valves for the tires. A suitably

designed hollow bolt 82 allows for the air to pass from the tube in the hollow axle 22 to the rotating seal in the hub cap 38. The sensor member 72 of the present invention allows for CTI but does not economically penalize the majority of applications where CTI is not used.

To protect the bearings 36, 38, the entire axle end area is sealed from moisture, dirt and other contaminants. Suitable venting is provided so that the seals within the wheel mounting apparatus 24 are not subjected to excessive pressure buildup. Depending on the wheel end construction, different methodologies may be used which use suitable vents in the hub cap 38, seals and/or the freeze plug 64. The sensor member 72 of the present invention is compatible with all such approaches. Consequently, the periphery of the body includes the L-shaped venting slots 81 such that pressure on both the front and back of the sensor member 72 remains equalized. As for a conventional wheel end construction, venting and sealing are controlled by the hub cap, freeze plug and bearing seals. It should be noted that, depending on the application and the method of lubrication of the bearings, all parts of the sensor member 72 may be subject to oil splash. The design and material of the sensor member 72 of the present invention allows for operation in this environment.

An electronic circuit assembly 84 is provided between the body 76 and the cover 78 of the sensor member 72. The electronic circuit assembly 84 includes a printed circuit board 86 mounted on the body 76 by suitable means such that the printed circuit board 86 is positioned between the body 76 and the cover 78 of the sensor member 72. Wires 90 extend from the printed circuit board 86 through the grommet in the freeze plug 64, through the hollow axle 22 to a current supplying controller 92. The controller 92 is preferably the ECM of the ABS or EBS of the trailer 26. If desired, a second controller can be provided.

Wheel speed and direction sensing elements 94, 96 are provided on the printed circuit board 86 in the form of an application specific integrated circuit (ASIC) 88. The preferred embodiment of the present invention uses “active” technology. The wheel speed and direction sensing elements 94, 96 are preferably a pair of hall effect

semiconductor elements. The hall effect semiconductor elements 94, 96 can be soldered to the printed circuit board 86 at the outermost end thereof and at spaced locations from each other. Preferably, however, the hall effect semiconductor elements 94, 96 are located on the same silicon chip. This aids in overall economy and, because of the use of standard integrated circuit fabrication techniques, relative location can be controlled. The face of each hall effect semiconductor sensing element 94, 96 is parallel to the axis of rotation of the axle 22.

The second side wall 50 of the hub cap 38 is machined to provide a recess in which the mounting wheel 75 is located. To secure the mounting wheel 75 to the inside of the second side wall 50, the metal second side wall 50 is deformed. This precisely locates the mounting wheel 75 on the hub cap 38. Because the hub cap 38 is precisely mounted on the wheel hub 32 and axle 22 as discussed herein, the mounting wheel 75 is precisely mounted on the wheel hub 32 and axle 22.

The exciting ring 74 is mounted on the inner surface of the mounting wheel 75 and is proximate to, but spaced from the hall effect semiconductor sensing elements 94, 96. Because the mounting wheel 75 is precisely mounted on the wheel hub 32 and axle 22, the exciting ring 74 is precisely mounted on the wheel hub 32 and axle 22. The exciting ring 74 and the sensor member 20 are concentric with each other when mounted. As such, a defined radial gap is provided between the exciting ring 74 and the hall effect semiconductor sensing elements 94, 96. The hall effect semiconductor sensing elements 94, 96 are mounted on the printed circuit board 86 so as to precisely line up with the exciting ring 74 when the hub cap 38 is mounted on the wheel hub 32.

Because the face of each hall effect semiconductor sensing element 94, 96 is parallel to the axis of rotation of the axle 22, a constant gap is maintained by the bearings 36. Axial movement of the wheel hub 32 does not have a significant effect and no gap adjustment is required. The gap is set by design, and gap variation is directly controlled by the bearings 36. The gap is dependent on the concentricity of the mounting of the exciting ring 74 within the hub cap 38.

In the preferred implementation, the exciting ring 74 is a multi-pole magnet

fabricated using ferrite in a plastic matrix material. Because the exciting ring 74 is carried on the mounting wheel 75 mounted inside the hub cap 38, the magnet poles can be located precisely both circumferentially around the sensor member 72 and radially relative to the sensor member 72. This positioning eliminates many of the difficulties associated with the prior art stamped exciting ring. As such, the gap between the exciting ring 74 and the hall effect semiconductor sensing elements 94, 96 is radial so that the gap is directly controlled by the position of the bearings 36 and is not influenced by axial movement of the wheel hub 32. Alternatively, a stamped, toothed ring can be used as the exciting ring 74.

The hall effect semiconductor sensing elements 94, 96 are spaced apart from each by an integral number of pole pairs or teeth, depending on the type of exciting ring 74 that is used, plus or minus approximately ninety degrees.

To allow for overall optimization of the sensor member 72 and for ABS function or EBS function, when the present invention is used in an ABS or EBS as described herein, the preferred embodiment of the exciting ring 74 does not conform to the present industry standard of one hundred teeth. Instead, the present invention uses twenty-five pole pairs in the exciting ring 74. These pole pairs are precisely located so that with use of suitable electronic resolution enhancement techniques, an information rate equivalent to fifty pole pairs using standard techniques is achieved.

FIGURE 8 illustrates a circuit which implements this resolution enhancement technique. Signals A and B originate from the hall effect semiconductor sensing elements 94, 96. Signals A and B are input into an XOR gate 118. The resulting waveform is generated as output C. Other suitable circuits can be used.

The details of the implementation of the sensor electronics using an available integrated circuit 120 is shown in FIGURE 9. The circuit as shown in FIGURE 9 includes integrated circuit 120, resistors 122, 124, and capacitors 126, 128, 130. A suitable integrated circuit 120 is an Allegro A3422LKA integrated circuit. The two hall effect semiconductor elements 94, 96 are embedded on one piece of silicon in the integrated circuit 120 such that the two hall effect semiconductor elements 94, 96 are

spaced a suitable distance for quadrature implementation. The Vcc pin 1 of integrated circuit 120 is a voltage input. The DIR pin 2 of integrated circuit 120 outputs direction information using high/low logic. The GND pin 3 of integrated circuit 120 is connected to ground. The SPD pin 5 of integrated circuit 120 outputs a frequency signal proportional to wheel speed. The SPD pin 5 of integrated circuit 120 implements the resolution enhancement functionality described earlier and shown in FIGURE 8. Resistor 124 is connected to pin 5. The EI pin 4 of integrated circuit 120 is connected to ground by resistor 122.

In operation, the wheel hub 32, the hub cap 38, the mounting wheel 75 and the exciting ring 74 rotate relative to the fixed axle 22 and the sensor member 72 mounted thereon. The controller 92 supplies electric current to the sensor member 72 which is a current sink. The hall effect semiconductor sensing elements 94, 96 sense whether a north pole or a south pole of the exciting ring 74 is present.

If a multi-pole magnet is used as the exciting ring 74, if a north pole is present, the hall effect semiconductor sensing elements 94, 96 sink 14 mamps, for example, from the controller 92, and if a south pole is present, the hall effect semiconductor sensing elements 94, 96 sink 7 mamps, for example, from the controller 92. This information is conveyed to another part of the ASIC 88, to obtain a square wave as the poles are going by. The controller 92 determines how many times the sensor member 72 switches between 14 mamps and 7 mamps. This change happens fifty times every revolution of the tire.

If a toothed wheel is used as the exciting ring 74 and a tooth is present, the hall effect semiconductor sensing elements 94, 96 sink 14 mamps, for example, from the controller 92. On the other hand, if a space is present, the hall effect semiconductor sensing elements 94, 96 sink 7 mamps, for example, from the controller 92. This information is conveyed to another part of the ASIC 88, to obtain a square wave as the poles are going by. The controller 92 determines how many times the sensor member 72 switches between 14 mamps and 7 mamps. This change happens fifty times every revolution of the tire.

The frequency of the change is proportional to the wheel speed. This information is used by the ABS or EBS to function in a like manner to how a conventional wheel speed sensor information is used to slow the trailer 26, if necessary.

The frequency output on the SPD pin 5 of integrated circuit 120 is implemented using high/low voltage levels. As implemented in the circuit shown in FIGURE 9, this voltage signal is converted into a two level current signal by the presence of resistor 124. SPD pin 5 pulls current through resistor 124 when SPD pin 5 is low. When SPD pin 5 is high, current is not pulled through resistor 124. The interface electronics then senses the current variation. This keeps the overall wiring interface to three leads, power, ground and direction. Current pulses in the power lead correspond to the passage of poles as the exciting ring 74 rotates or to the passage of teeth if a toothed ring is used. The E1 signal output on pin 4 from integrated circuit 120 from the integrated circuit is not required in this application and is held at ground by resistor 122. The capacitors 126, 128, 130 provide noise suppression.

The integrated circuit 120 does not output a current, such that a low is provided, on DIR pin 2 when the trailer 26 is backing up. The controller 92, which is the ECM of the ABS or EBS, detects that the integrated circuit 120 is not outputting current and determines that the trailer 26 is backing up. This information is used by the controller 92 of the ABS or EBS to activate the circuitry to perform the desired function or functions, such as sounding an audible back-up alarm and/or lighting a back-up lamp. Because the forward and reverse wheel speed information is available to the controller 92, the information can be used to provide enhanced functionality over and above that of ABS or EBS without the forward and reverse wheel speed information.

Auxiliary pin 7 of the J560 connector can be used, for example, to power an audible back-up alarm and/or a back-up lamp. The controller 92 has an electrical switching element which provides power to the audible back-up alarm and the back-up lamp when the trailer 26 is moving in reverse. FIGURE 10 shows an

implementation of the overall system. The controller 92, in addition to being connected to the integrated circuit 120, is connected to pin 7 of the J560 connector through a voltage regulator 132. As such, when the ignition is turn on, power is supplied to pin 7 and thus to the controller 92. The controller 92 is also connected to a resistor 134 which is connected to the base of a transistor 136. The emitter of the transistor 136 is connected to ground. The collector of the transistor 136 is connected to an inductor of a coil inclusive relay 138. The opposite side of the inductor of the coil inclusive relay 138 is connected to the voltage regulator 132. A diode 140 is connected to both sides of the inductor of the coil inclusive relay 138. Pin 7 is connected to one side of the relay of the coil inclusive relay 138. The other side of the relay of the coil inclusive relay 138 provides 12V for the audible back-up alarm and the back-up lamp.

In operation, the controller 92 utilizes the direction input from the DIR pin 2 of the integrated circuit 120 to turn on the transistor 136. The allows the current from Pin 7 of the J560 connector to flow through the transistor 136, thereby closing the relay. Because the relay is closed, power flows through the relay from Pin 7 of the J560 connector to provide power for the audible back-up alarm and back-up lamp, or for any other purposes.

As noted earlier many tractors have power available on Pin 7 of the auxiliary connector. In all cases, on new trailers, Pin 7 is connected to the ECM of the ABS or EBS. It should also be noted that this power supply, under current mandated requirements, is not required to be dedicated solely to the ABS function or EBS function.

In a preferred implementation, the power is not activated solely on the basis of whether the direction sensor gives an indication of reverse movement. The controller 92, under stored program control, implements delays before switching on or off power. This avoids the irritation of flashing back-up lamps and ensures that the back-up lamps remain on when the driver stops briefly during a back-up maneuver. Such stops are very common, particularly when backing up tractor-trailer combinations.

The light level is also sensed by a suitable sensor (not shown) mounted on the trailer 26 and in communication with the controller 92 so that the back-up lamps do not illuminate if they are not required. These and other variations will be apparent to those skilled in the art.

Individual active sensors are the preferred sensors for the present invention. The chips which implement the Hall effect function are small. Relative location can be tightly controlled by mounting on the same printed circuit board. The two hall effect semiconductor elements 94, 96 can be located on the same silicon chip. This aides overall economy and, because of the use of standard integrated circuit fabrication techniques, relative location becomes almost a non-issue. Two integrated circuits can be provided on the silicon chip, each having a hall effect element thereon.

It is to be understood that conventional VR sensors can be used instead of hall effect semiconductor sensing elements 94, 96.

While a preferred embodiment of the present invention is shown and described, it is envisioned that those skilled in the art may devise various modifications of the present invention without departing from the spirit and scope of the appended claims.